

THE "GOLDILOCKS" PRINCIPLE

Name: _____

Date: _____ Score: _____

Problem: Without greenhouse gases, what would happen to the Earth?

Background

On Earth, two molecules, nitrogen (N_2) and oxygen (O_2), make up almost 99% of the volume of clean, dry air. Most of the remaining 1% is accounted for by the inert gaseous element, argon (Ar). Argon and the tiny percentage of remaining gases are referred to as trace gases. Certain trace atmospheric gases help to heat up our planet because they appear transparent to incoming visible (shortwave) light but act as a barrier to outgoing infrared (long wave) radiation. These special trace gases are often referred to as "**greenhouse gases**" because a scientist in the early 19th century suggested that they function much like the glass plates found on a greenhouse used for growing plants.

The earth's atmosphere is composed of gases (for example, CO_2 and CH_4) of just the right types and in just the right amounts to warm the earth to temperatures suitable for life. The effect of the atmosphere to trap heat is the true "**greenhouse effect**."

We can evaluate the effect of greenhouse gases by comparing Earth with its nearest planetary neighbors, Venus and Mars. These planets either have too much greenhouse effect or too little to be able to sustain life as we know it. The differences between the three planets have been termed the "**Goldilocks Principle**" (Venus is too hot, Mars is too cold, but Earth is just right).

Mars and Venus have essentially the same types and percentages of gases in their atmosphere. The atmospheres of both of them are primarily CO_2 and they are very different from the Earth. However, they have very different atmospheric densities.

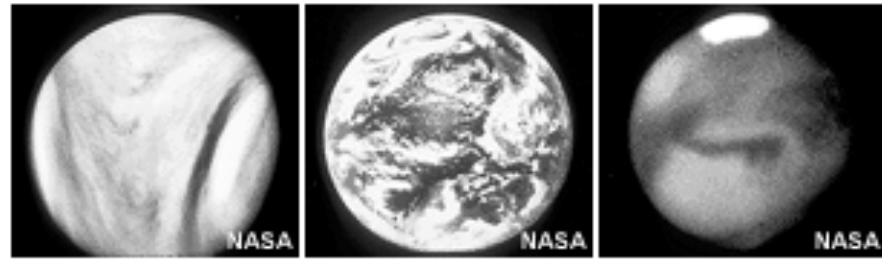
Venus has an extremely dense atmosphere, so this density combined with the concentration of CO_2 (96.5% of the atmosphere) is responsible for a strong greenhouse effect and a very high surface temperature.

Mars has almost no atmosphere; therefore the amount of CO_2 (95% of the atmosphere) although similar to that of Venus is not sufficient to supply a warming effect and the surface temperatures of Mars are very low.

Mars is much further away from the Sun than is Venus.

Adapted from The Goldilocks Principle: A Model of Atmospheric Gases http://www.ucar.edu/learn/1_1_2_1t.htm

Data on Earth, Venus Mars



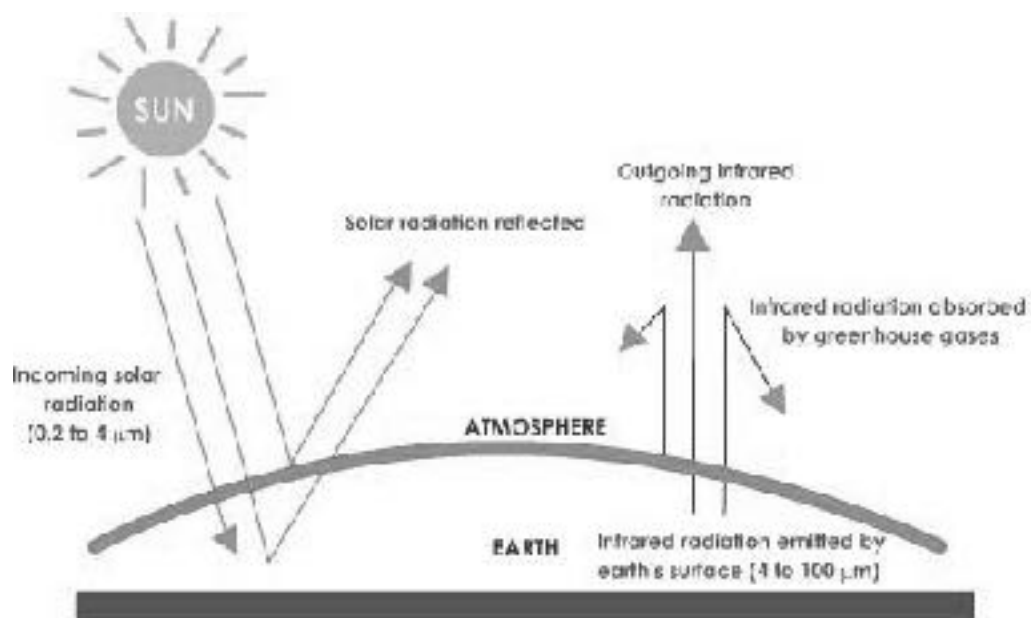
Venus

Earth

Mars

Surface pressure relative to Earth (bars)	90	1	0.007
Major greenhouse gases (GHG)	CO ₂	H ₂ O, CO ₂	CO ₂
Temperature if no GHG (°C)	-46	-18	-57
Actual temperature (°C)	477	15	-47
Temperature change due to GHG	+523	+33	+10

Carbon Dioxide (CO ₂)	96.5%	0.03%	95%
Nitrogen (N ₂)	3.5%	78%	2.7%
Oxygen (O ₂)	Trace	21%	0.13%
Argon (Ar)	0.007%	0.9%	1.6%
Methane (CH ₄)	0	0.002%	0



Record the data to compare Venus, Earth, & Mars

Temperature and Pressure Comparison	VENUS	EARTH	MARS
Surface Pressure Relative to Earth			
Estimated Temperature if No Greenhouse Gases (°C)			
Actual Temperature (°C)			
Temperature Change Due to Greenhouse Gases			

Atmospheric Concentrations of Greenhouse Gases (%)	VENUS	EARTH	MARS
Carbon Dioxide (CO ₂)			
Nitrogen (N ₂)			
Oxygen (O ₂)			
Argon (Ar)			
Methane (CH ₄)			

1. Why is it so much colder on Mars than on Venus, even though they have similar amounts of carbon dioxide?
2. Name at least two ways that the atmospheres of Venus and Mars are similar to each other, and one way that both differ from Earth's.

3. Why do we call this the “Goldilocks” principle?
4. What could you infer about Earth’s future if we increase the amount of carbon dioxide into the atmosphere?